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# *A New, Portable, Real-time Ozone Monitor*

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# *Introduction*

- ◆ People spend ~90% of time indoors
- ◆ Ozone routinely monitored outdoors
- ◆ Ozone penetration factor ranges from 0.1 to 0.9
- ◆ Need to understand indoor levels to assess and control ozone exposure

# *Ozone Exposure Assessment*

- ◆ Epidemiological studies of adverse health effects
- ◆ Ozone control strategies / regulatory standards
- ◆ Methods of assessing ozone exposure
  - ✦ direct measurement
  - ✦ indirect measurement
  - ✦ modeling

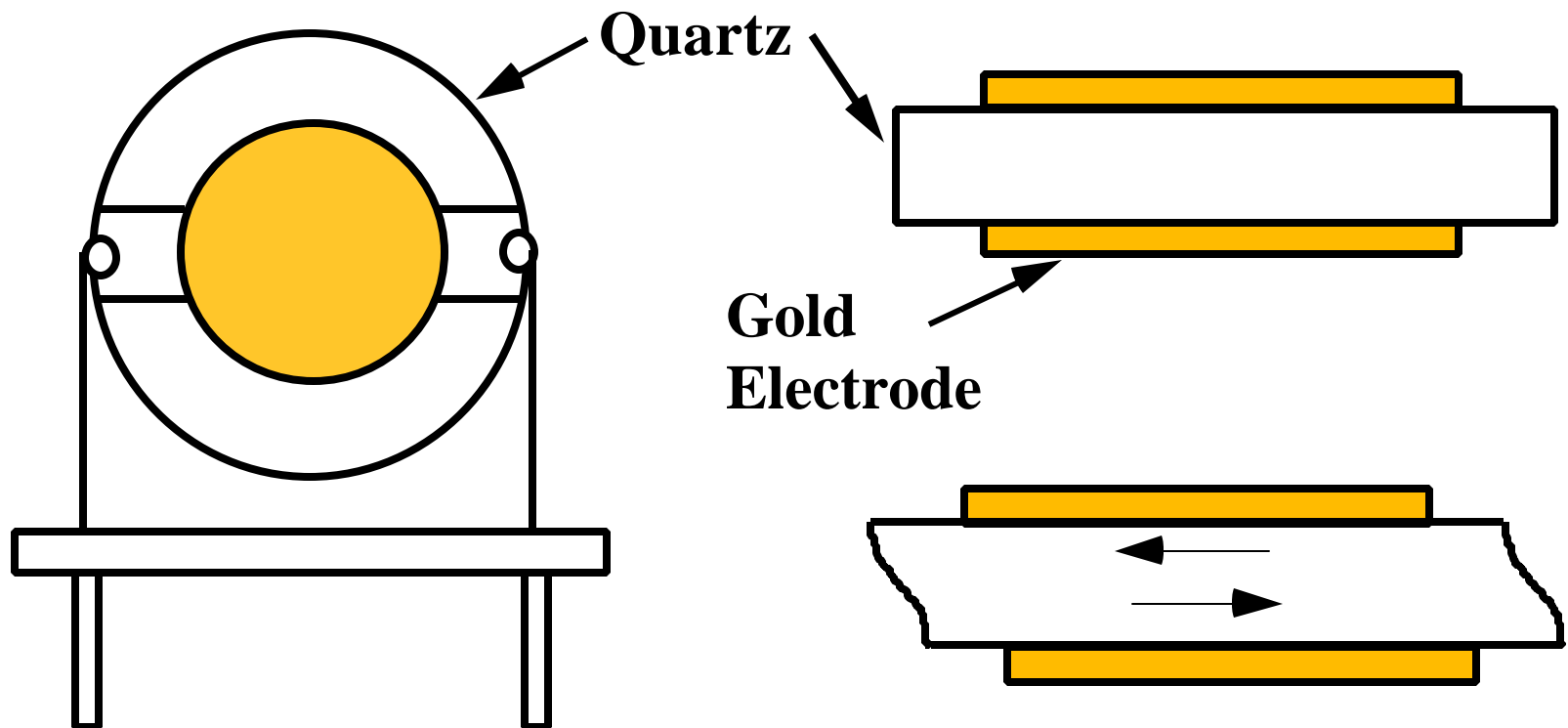
## *Need for Portable Ozone Monitor*

- ◆ Assessment of exposure requires accurate characterization of indoor ozone
  - ✦ UV ozone monitors are large, noisy, and expensive
- ◆ Assessment of acute ozone exposures requires high temporal resolution
  - ✦ diffusive badge samplers provide ozone concentration averaged over 8 hours or more and require costly and time-consuming lab analysis

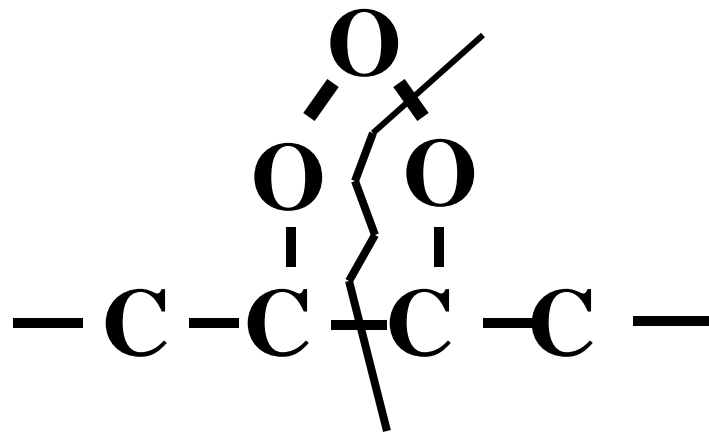
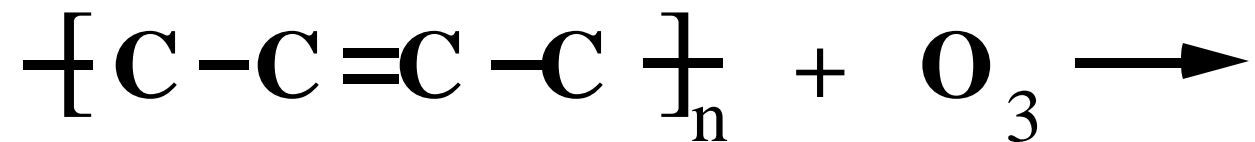
# *Sensor Design*

- ◆ Piezoelectric quartz crystal
- ◆ Polybutadiene coating
- ◆ Reaction with ozone causes mass increase and decrease in oscillation frequency
- ◆ Rate of change of frequency is proportional to ozone concentration

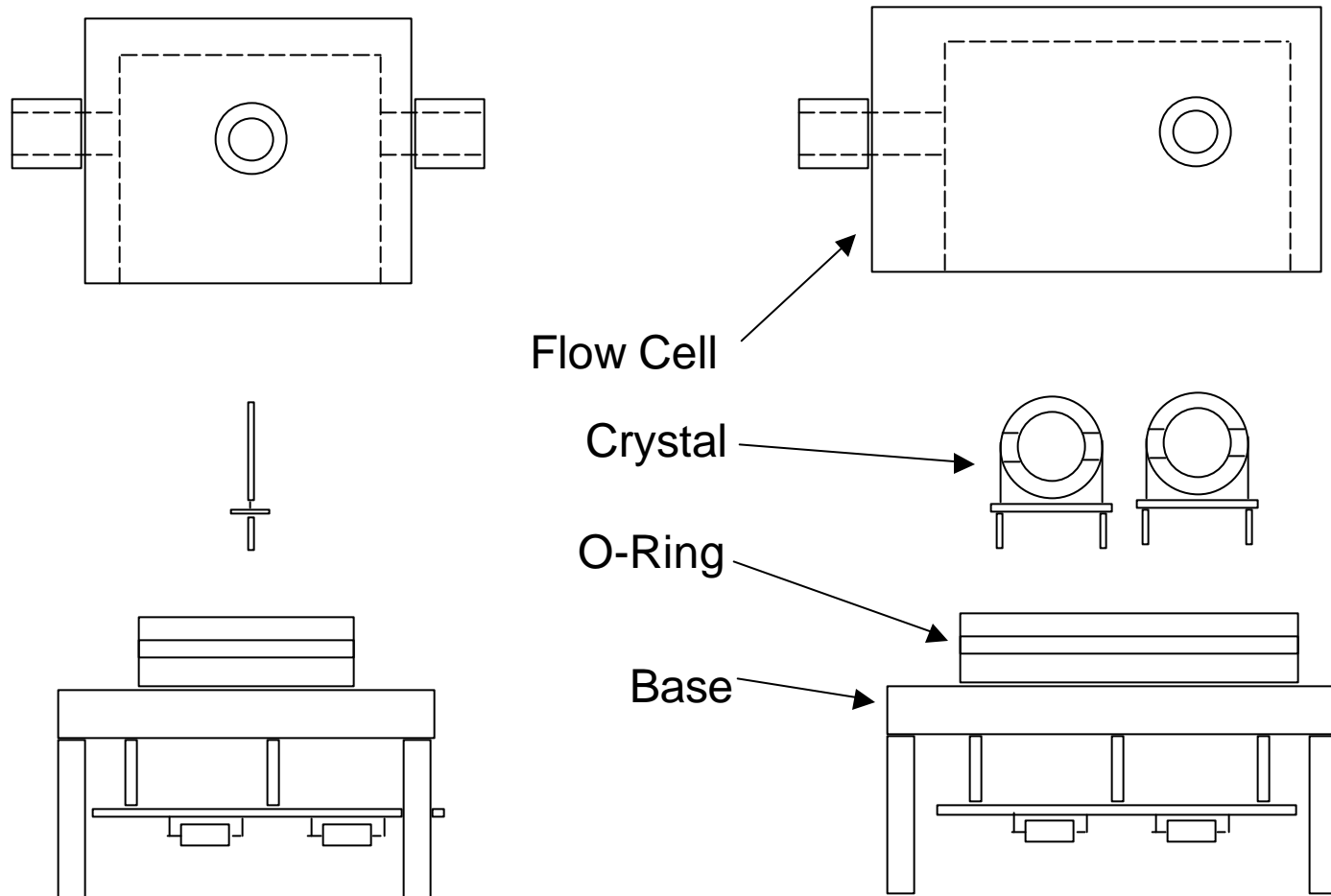
# *Piezoelectric Quartz Crystal*



## *Ozone / Polybutadiene Chemistry*



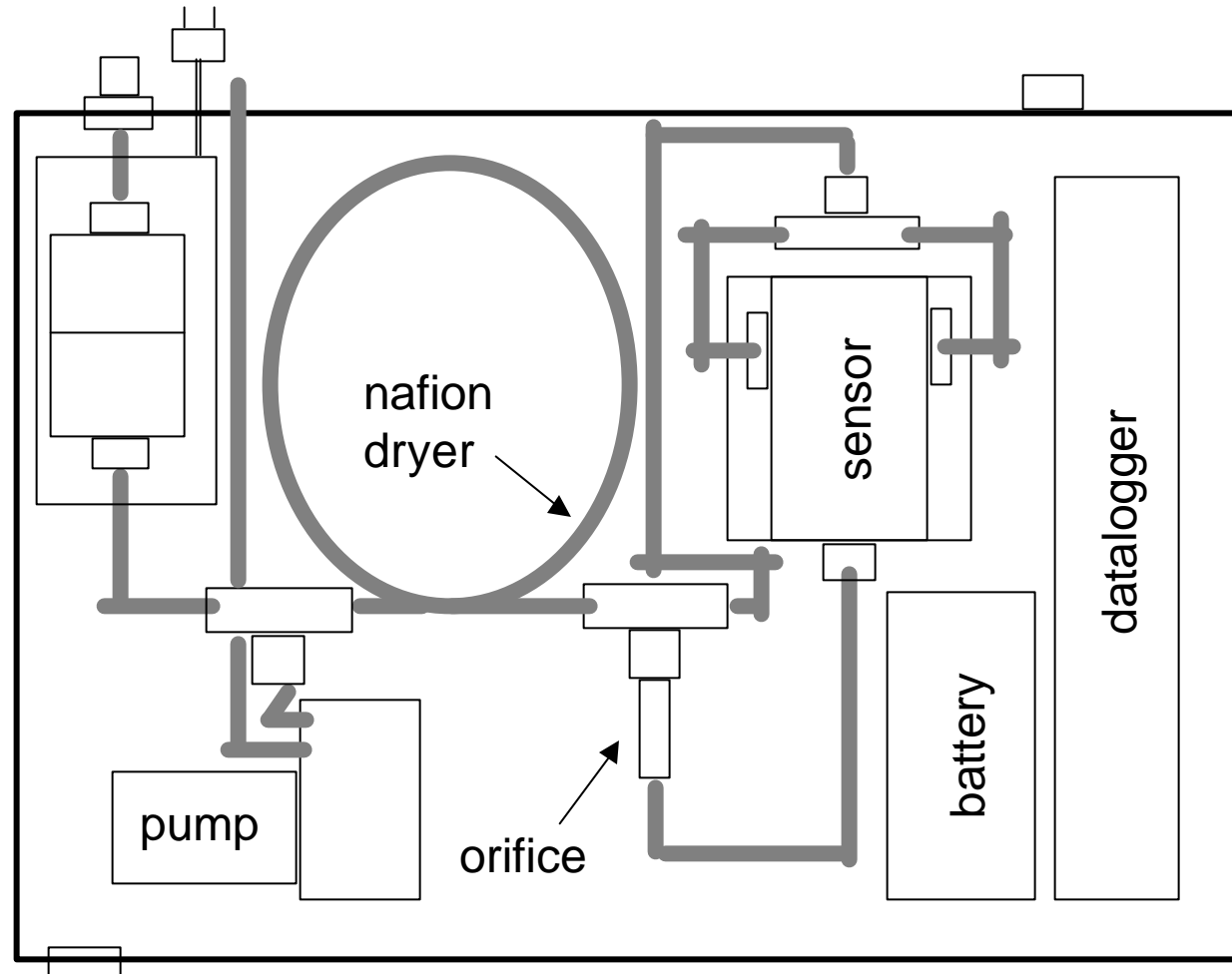
# *Sensor Housing*



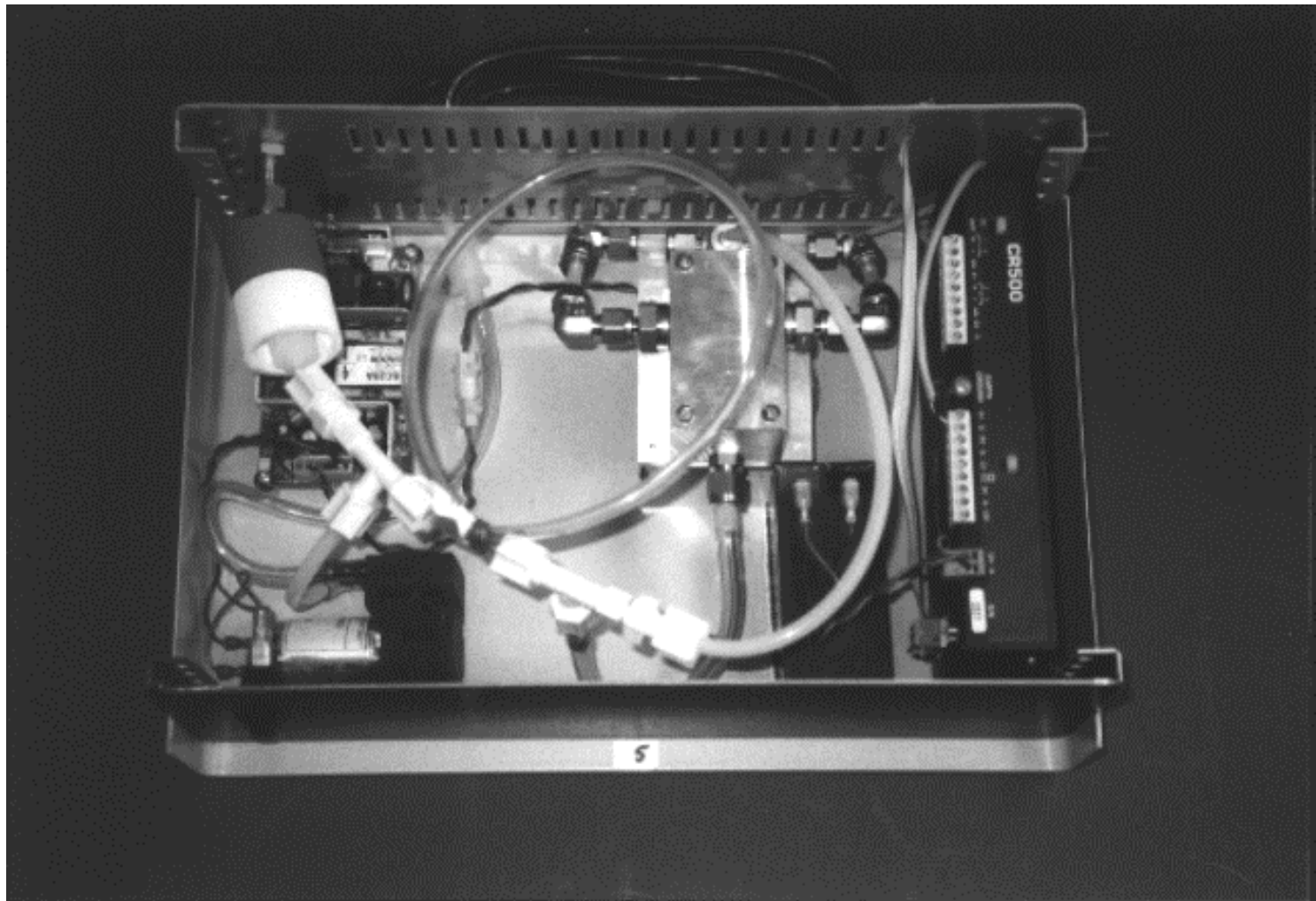
# *Portable Ozone Monitor*

- ◆ Stand-alone unit
  - ✦ sampling pump
  - ✦ programmable datalogger
- ◆ Teflon filter to remove particles
- ◆ Nafion dryer to remove water vapor
- ◆ Flow control by critical orifice

# *POM Component Layout*



# *POM Component Layout*



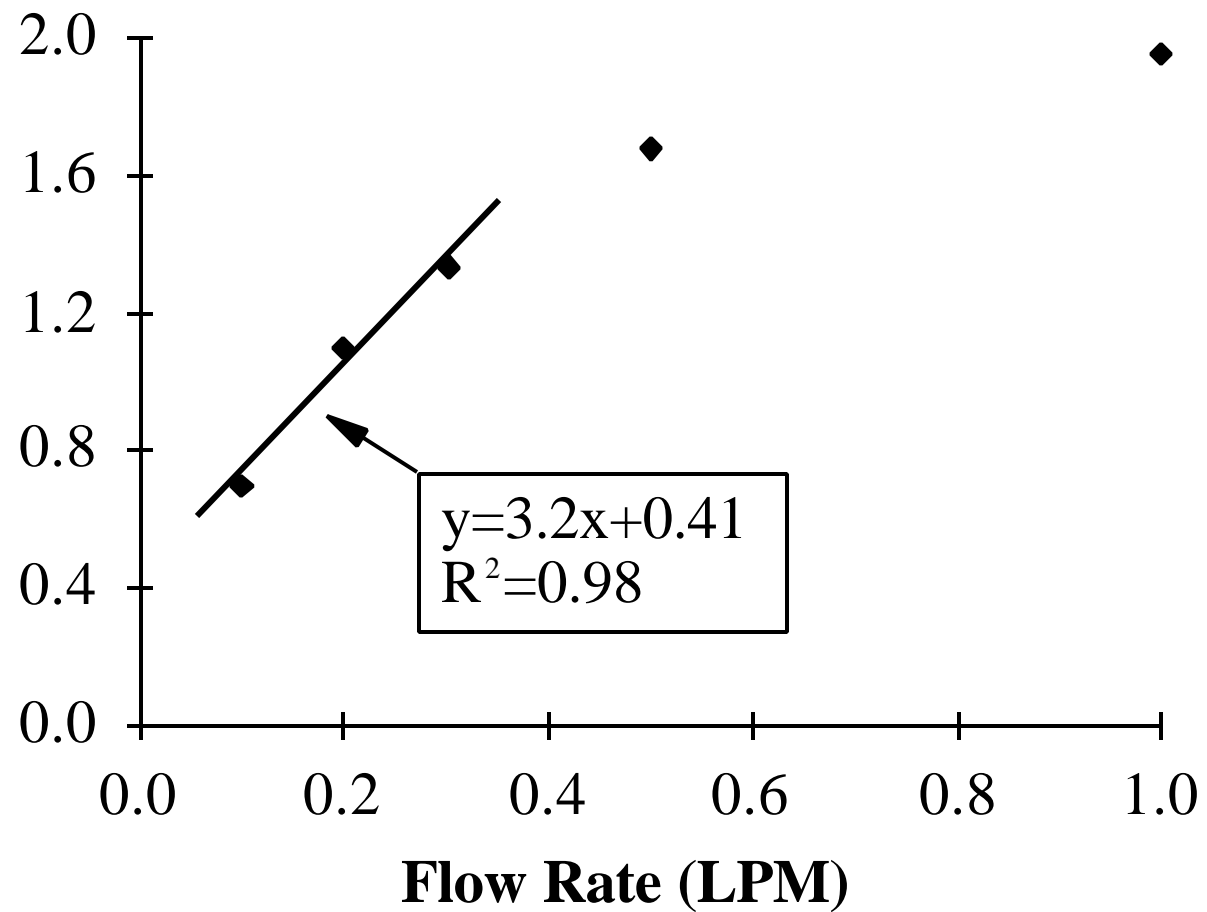
# *Monitor Operation*

- ◆ Coat crystals to be used for sampling
- ◆ Install and condition crystals
- ◆ Run sampler (1000 ppb-hr)
- ◆ Download ozone concentration data from logger with laptop PC
- ◆ Remove crystals, clean, and re-coat

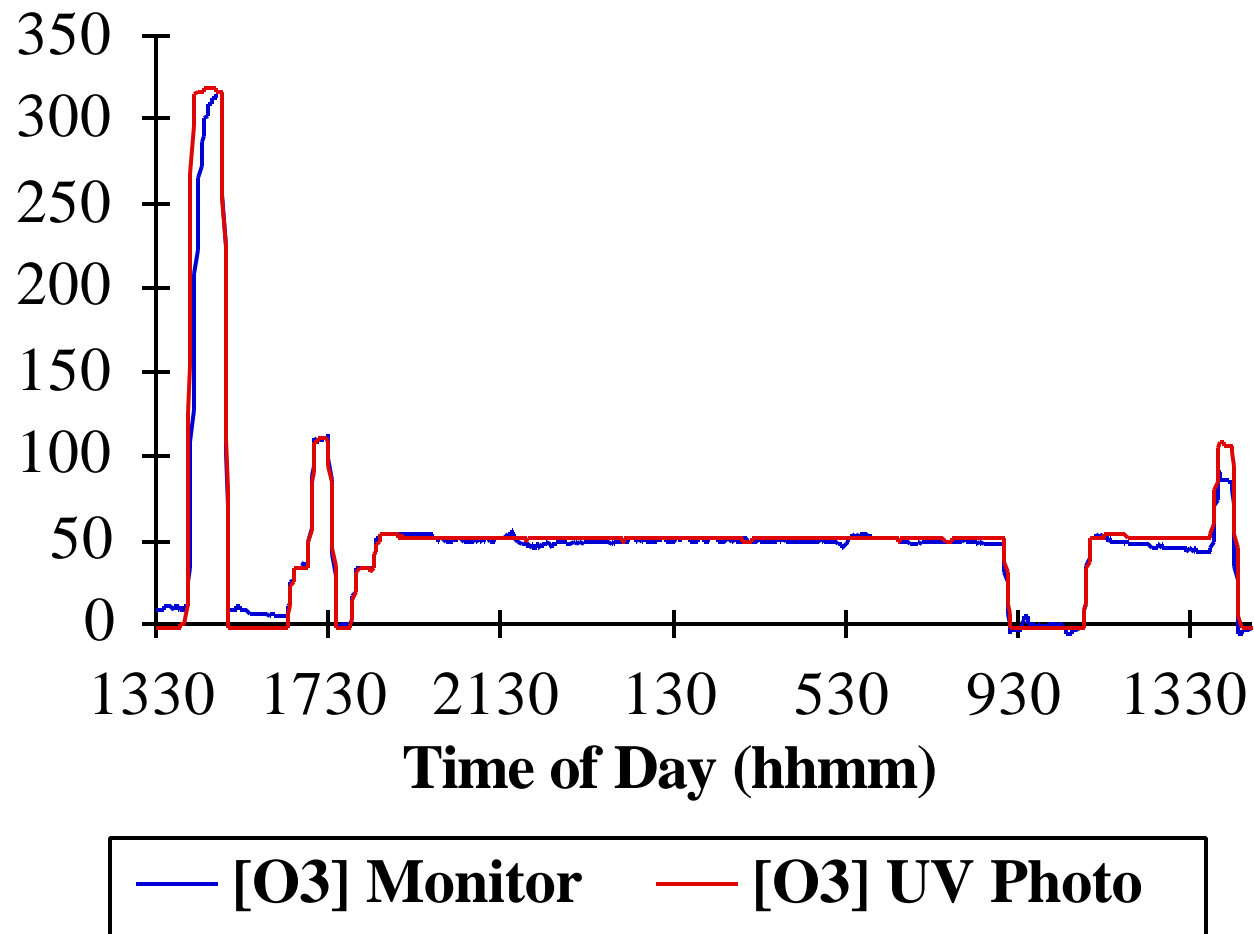
# *Laboratory Testing*

- ◆ Vary sample air flow rate
- ◆ Calibration
- ◆ Interference testing
  - ✦  $\text{NO}_2$ , water vapor,  $\text{NO}$ ,  $\text{HNO}_3$ , and toluene

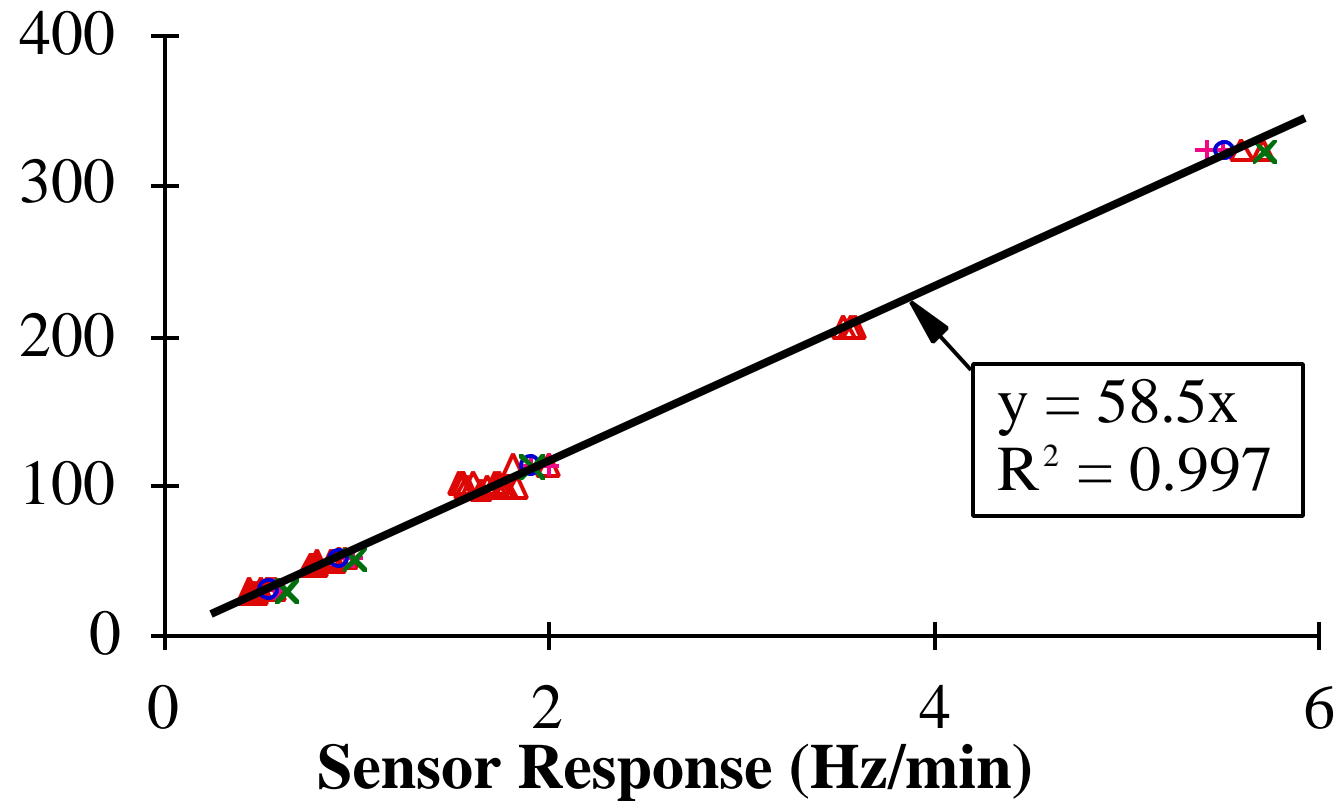
## *Sensor Response vs. Air Flow Rate*



## *POM Measurements in Lab over 24 hrs*

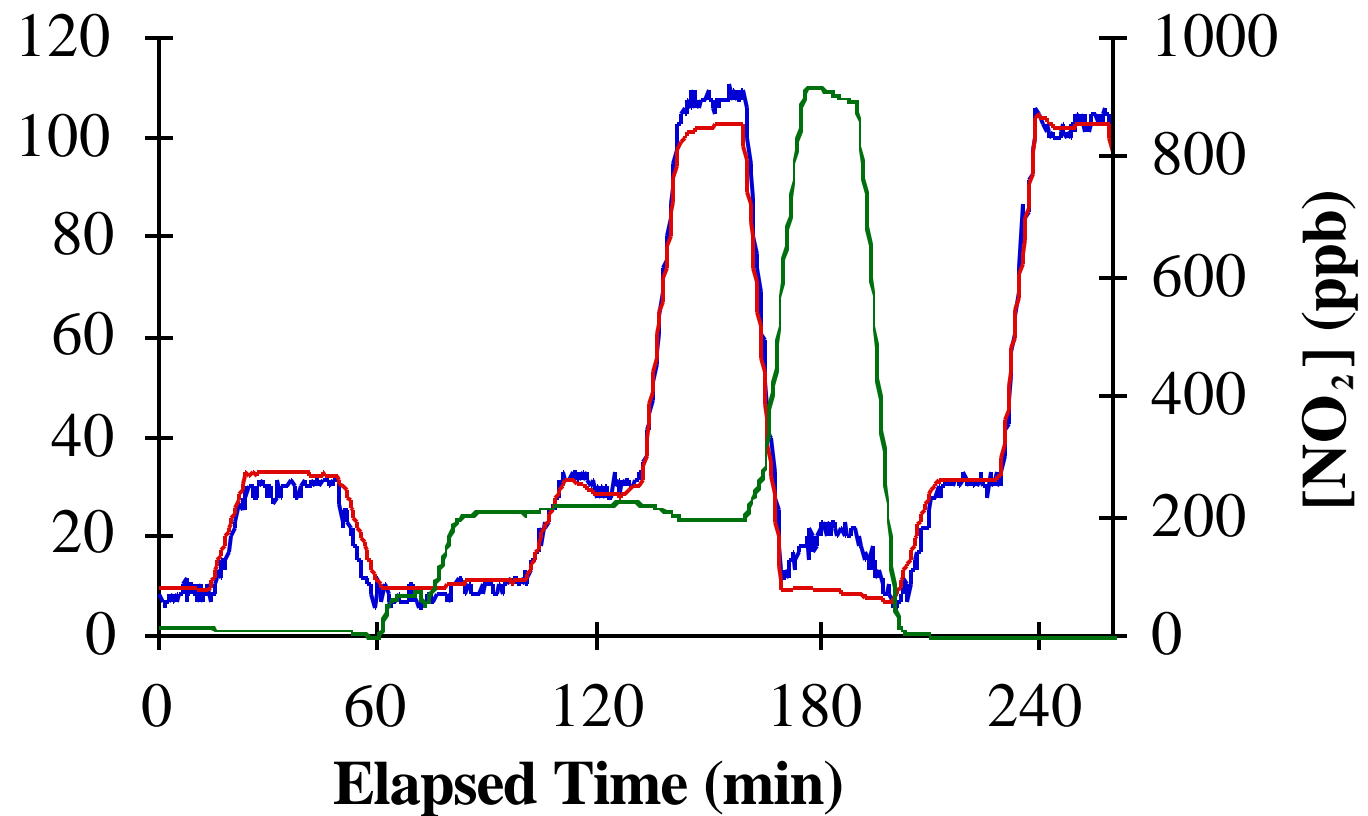


# *Monitor Calibration Curve*



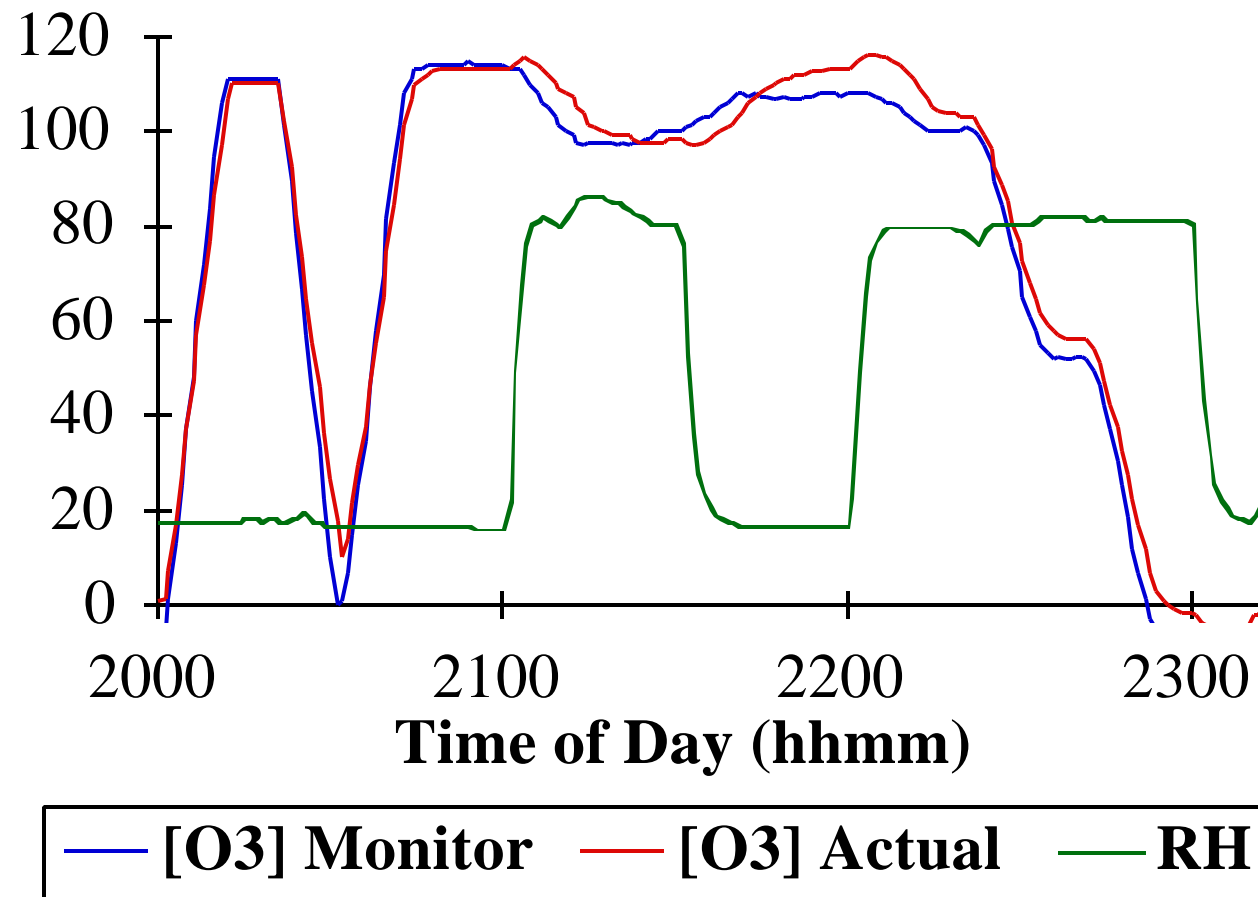
△ 8 kHz    + 10 kHz    ○ 12 kHz    × 14 kHz

# *Sensor Response to Ozone and NO<sub>2</sub>*



— [O3] Sensor    — [O3] Actual    — [NO2]

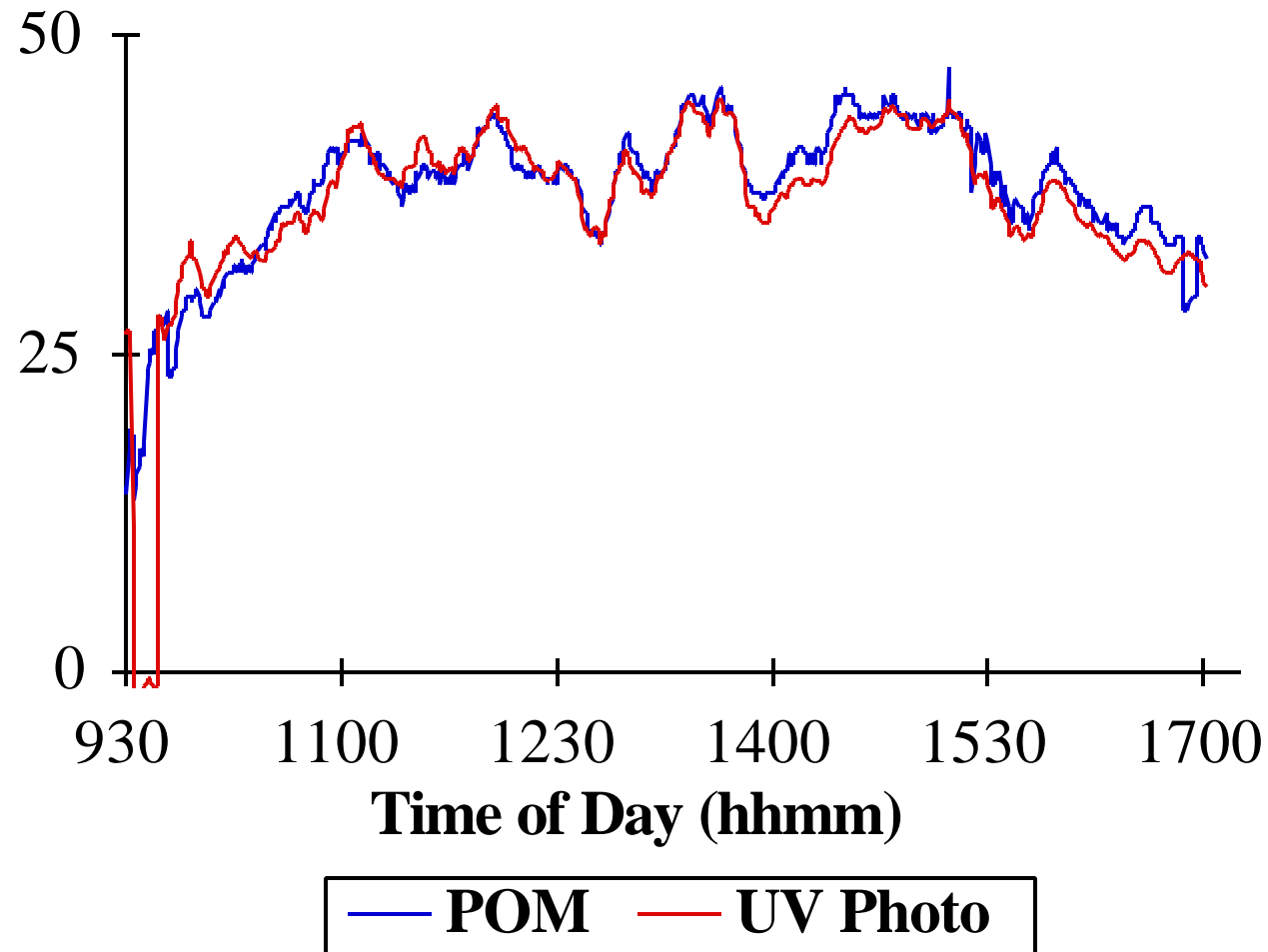
# *Sensor Response to Ozone and Water Vapor*



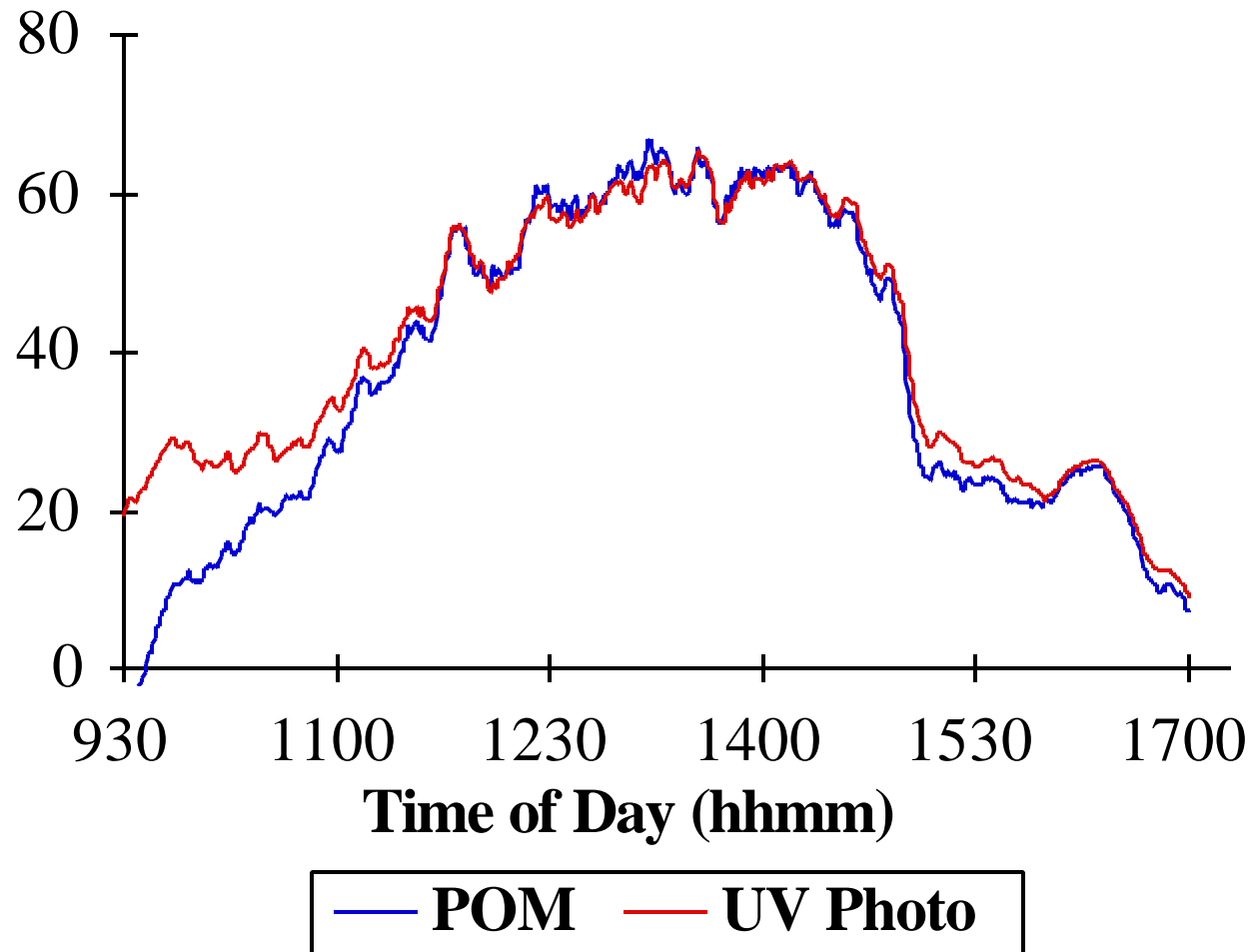
## *Field Sampling*

- ◆ Offices in Riverside
  - ✦ two POMs, one UV monitor indoors
  - ✦ building ventilation fixed
- ◆ Residences in Pasadena
  - ✦ two POMs, one UV monitor indoors
  - ✦ one POM, one UV monitor outdoors
  - ✦ vary ventilation with doors and windows

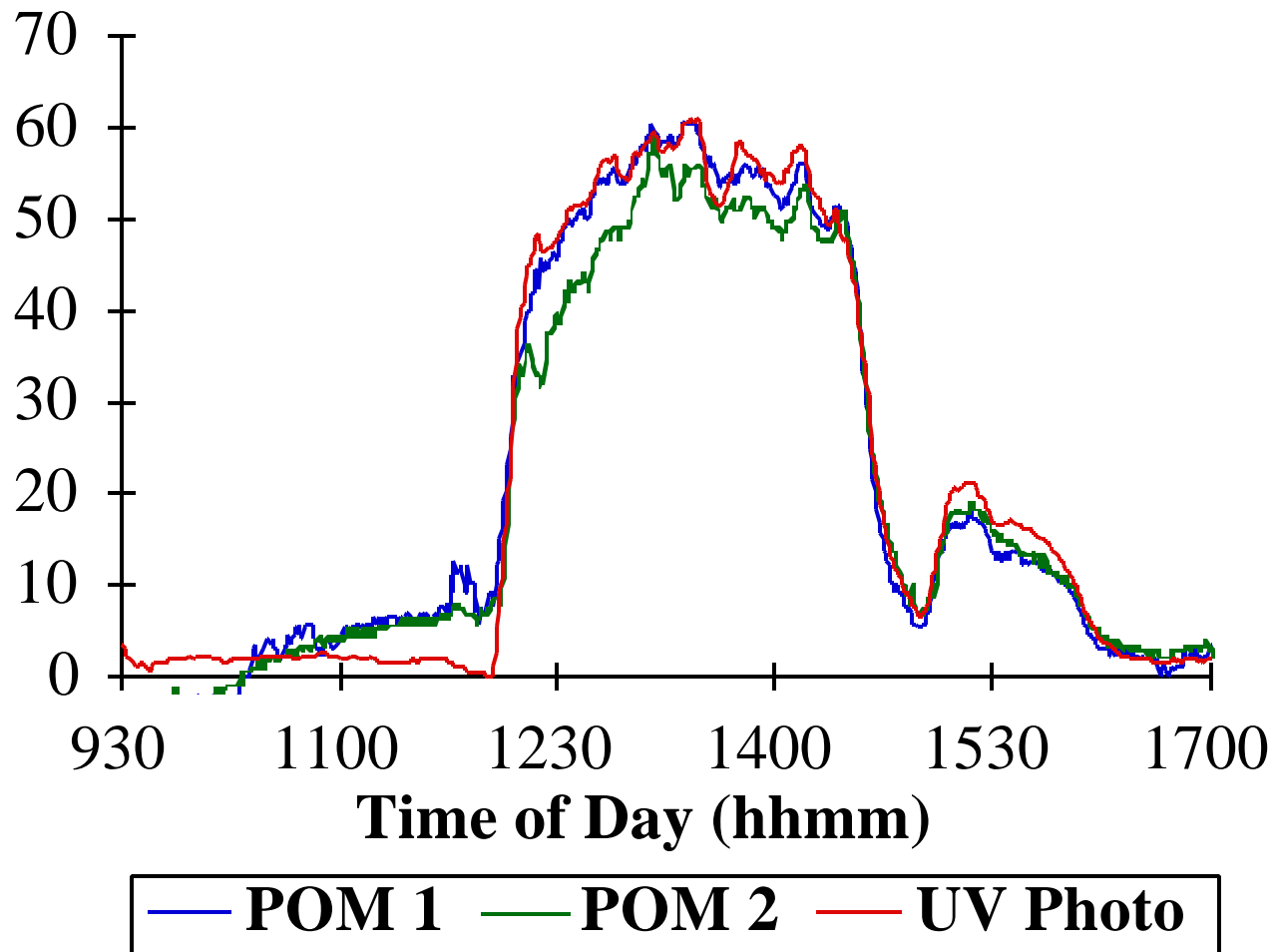
## *Outdoor POM Measurements at Residence 1*



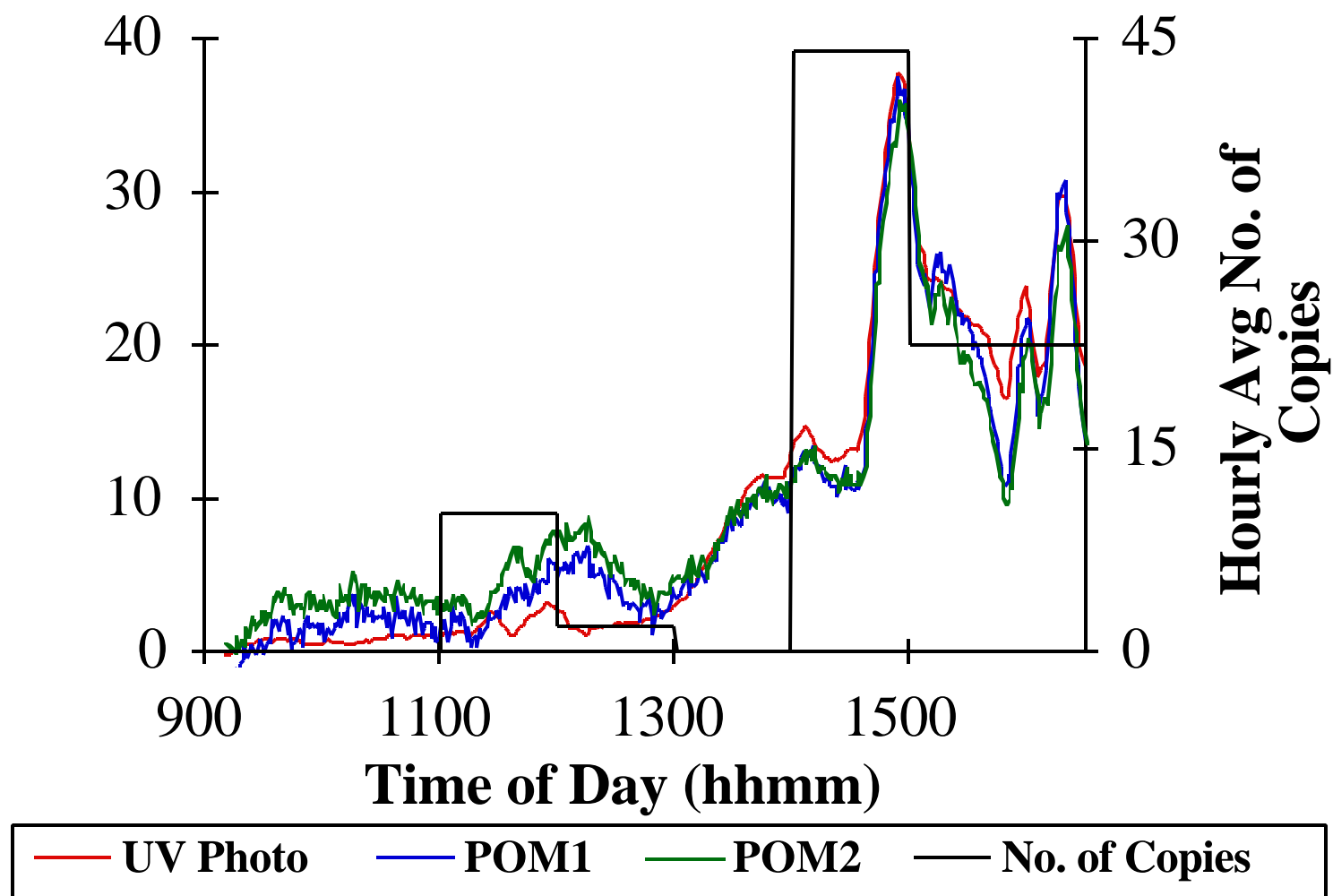
## *Outdoor POM Measurements at Residence 2*



## *Indoor POM Measurements at Residence 2*



# *Photocopy Room Measurements*



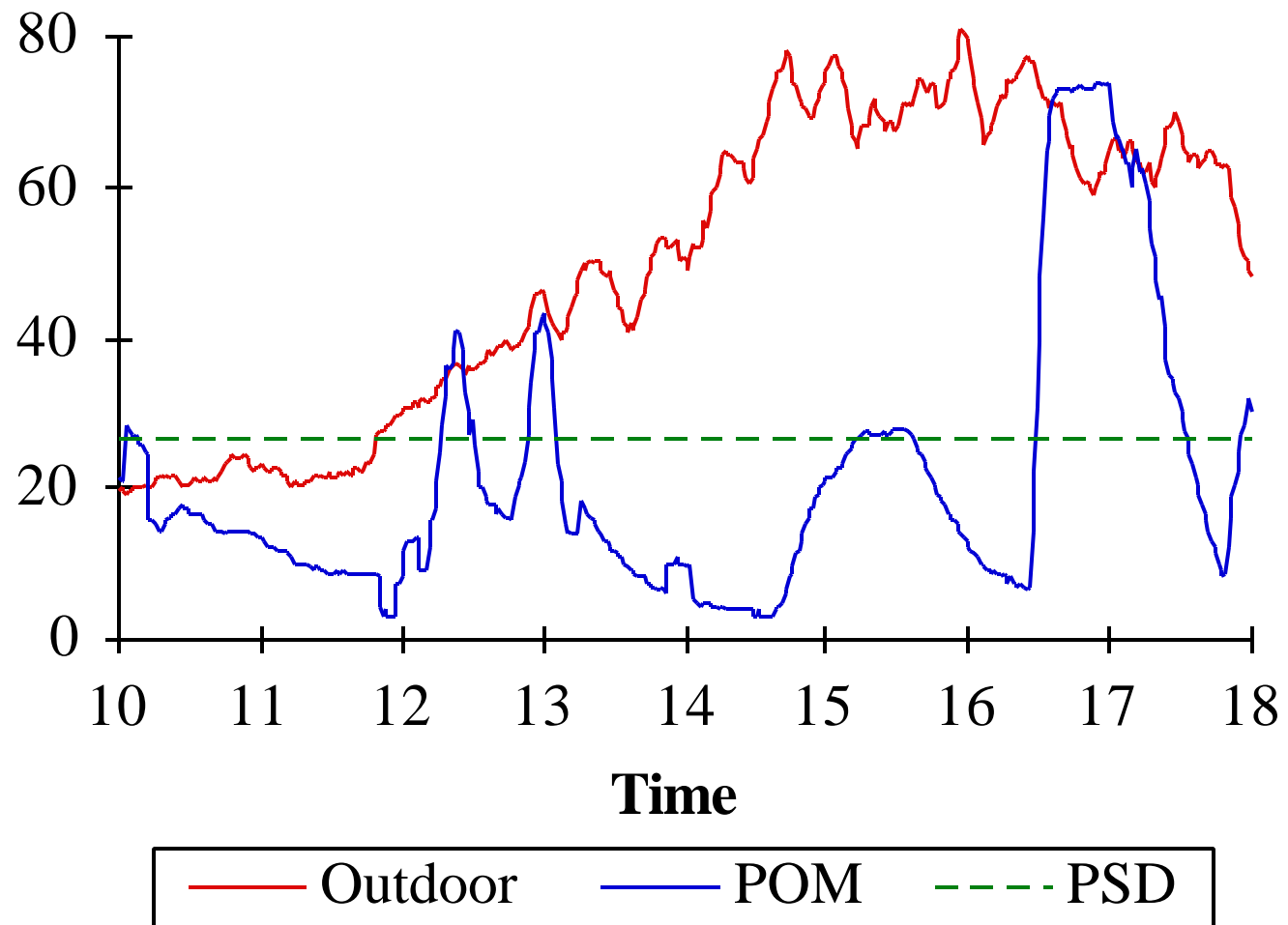
## *Significance of New Monitor*

- ◆ Low-cost, small-size, and real-time measurements
  - ✦ schools, hospitals, nursing homes, in-transit
  - ✦ assess indoor ozone sources
  - ✦ exposure model development
- ◆ Technology has potential for personal monitoring

# *Personal Monitoring*

- ◆ Prototype battery-operated monitor
  - ✦ personal sampling pump
  - ✦ Nafion dryer with desiccant
- ◆ Lighter, smaller enclosure
- ◆ Fits in standard backpack
- ◆ Preliminary tests with two subjects in Sacramento

# *Personal and Outdoor Ozone Measurements*



# *Acknowledgments*

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- ◆ California Air Resources Board
  - ✦ Tom Phillips and Peggy Jenkins